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Special Article - Further Developments in the Analysis of Productivity Growth in Australia

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INTRODUCTION

Productivity improvement is the growth in a nation's output over and above that explained by growth in the inputs to production. Measures of productivity growth are important to understanding long-term improvements in Australians' living standards and changes in Australia's international competitiveness. For some years, the ABS has published a variety of productivity estimates for the 'market'[1] sector of the economy:

- labour productivity, estimated by dividing an index of real output by an index of labour input;
- capital productivity, estimated by dividing an output index by an index of capital input; and
- multifactor productivity (MFP), estimated by dividing an output index by an index of labour and capital inputs combined.

The latest Australian productivity estimates are contained in tables 20-22 of the publication **Australian System of National Accounts, 2000-01** (Cat. no. 5204.0). The data from these tables are presented at the end of this feature article.

In recent years, the ABS has devoted considerable effort to extending and enhancing its productivity estimates. For example, the MFP calculations now take account of the flow of capital services into production rather than the former proxy measure based on the stock of capital. (For a description of this work see the feature article in the 1997-98 issue of Cat. no. 5204.0.) Also, better measures of output have been developed for service industries such as Property and business services, Health and Education-although these industries are not included in the 'market' sector for which productivity estimates are derived. (For a description of this work, see the feature article in the March quarter 2001 issue of this publication (Cat. no. 5206.0)).

This article describes three separate streams of work that the ABS has engaged in recently or is about to engage in to further extend the analysis of Australia's productivity growth. The three streams are:

- identifying the contribution of investment in computer hardware and software to productivity growth;
- the development of experimental estimates of labour input that take account of changes in the quality of labour; and

- assessing the contribution of intermediate inputs to productivity growth and exploring ways of constructing MFP estimates for individual industries.

[1] The market sector is defined as ANZSIC divisions A to K and P (see paragraph 36 of Explanatory Notes).

CONTRIBUTION OF INVESTMENT IN INFORMATION TECHNOLOGY

One way of analysing the contribution of investment in computer hardware and software (or information technology (IT)) to labour productivity growth is to use the growth accounting identity that says that labour productivity growth can be expressed as the sum of multifactor productivity (MFP) growth and the contribution of increased capital intensity or capital deepening (i.e. increases in the capital/labour ratio). Increased capital intensity means that, on average, each unit of labour has more capital to work with to produce output. 'Capital' here refers to the flow of capital services coming from the stock of capital, and is analogous to the hours worked by labour. The contribution of growing capital intensity to labour productivity growth equals the change in the capital/labour ratio multiplied by capital's share of total payments for inputs. The latter is assumed to be equal to capital's share of income from production, which is mostly the gross operating surplus. For a detailed discussion of how changes in capital intensity and MFP relate to labour productivity, see the Occasional paper: **Estimates of Multifactor Productivity, Australia** (Cat. no. 5233.0).

From 1964-65 to 1999-2000, output per hour worked (labour productivity) in the market sector grew at a compound annual rate of 2.4%. Of this growth, 1.1% can be attributed to increases in multifactor productivity, 0.4% to the contribution of increased capital intensity relating to IT capital services and 0.8% to the contribution of increased capital intensity relating to the capital services of other forms of capital. Investment in IT was insubstantial prior to 1985, so a clearer picture of the contribution of IT can be gained by looking at shorter time spans. In the table below the time spans relate to MFP growth cycles, the starts and ends of which are determined by peaks in the MFP growth cycles. Confining the analysis to MFP growth cycles excludes variations due to the business cycle. For an explanation of MFP growth cycles see 5233.0.

The following table shows compound average annual rates of growth in output per hour worked for the market sector and the contributions to its growth from MFP and capital intensity. The data show that the contribution of growing capital intensity of IT to growth in labour productivity has been generally rising over time. Indeed, during the latter part of the 1990s it accounted for the bulk of the contribution of rising capital intensity and has clearly played a major role in the growth of Australia's labour productivity. For further information on this work, contact Charles Aspden on phone (02) 6252 6646 or e-mail **charles.aspden@abs.gov.au.**

CONTRIBUTIONS TO GROWTH RATES IN LABOUR PRODUCTIVITY(a)

	1964-65 to 1999-00 %	1964-65 to 1968-69 %	1968-69 to 1973-74 %	1973-74 to 1981-82 %	1981-82 to 1984-85 %	1984-85 to 1988-89 %	1988-89 to 1993-94 %	1993-94 to 1999-00 %
Output per hour worked	2.4	2.5	2.9	2.4	2.2	0.8	2.0	3.0
Total capital intensity(b)	1.2	1.3	1.4	1.4	1.5	0.4	1.3	1.1
Information technology(b)	0.4	0.1	0.1	0.3	0.3	0.5	0.7	0.8
All other capital services(b)	0.8	1.2	1.3	1.1	1.2	-0.1	0.6	0.3

Multifactor productivity	1.1	1.2	1.5	1.0	0.8	0.4	0.7	1.8

(a) Compound annual average rates of growth.
(b) Growth in capital intensity multiplied by capital's share of income.

QUALITY-ADJUSTED INDEX OF LABOUR INPUT

When measuring labour productivity or multifactor productivity there are several choices of how to measure labour input.

The crudest measure is the **number of persons employed**. But this takes no account of changes in the mix of full-time and part-time work or, say, changes in overtime or reduced hours. Thus, it may mistakenly ascribe the effects of changes in average hours worked to productivity change.

A better measure is the **number of hours worked**. This is the labour input measure that underlies the estimates of labour productivity and MFP currently published by the ABS. A shortcoming of this measure is that it does not take account of changes in the aggregate quality of labour due to, say, an increase in the prevalence of highly qualified people. Changes in aggregate labour quality are currently ascribed to changes in productivity, but there is an argument that they should be viewed instead as changes in inputs in a way to analogous to changes in the mix of different types of capital services.

Hence, a better measure still would be the **number of hours worked, adjusted for changes in the quality or composition of labour**.

The ABS has compiled an experimental annual quality-adjusted series for hours worked. The method and results are discussed in the following sections.

Method

The quality adjusted hours worked series has been compiled using the following steps:

theory and previous empirical studies were examined to ascertain which

- characteristics (or 'dimensions') of labour input are likely to have significant effects

on the quality of labour;

- an array of hours worked data was assembled, using the dimensions suggested by

the first step;

- an array of weighting factors was assembled to reflect the differential quality of

labour; and

- a chain-weighted, quality-adjusted index of hours worked was constructed.

Two key assumptions underlying the ABS experimental index are that differential hourly wage rates reflect differential quality of labour, and that the quality of labour can be encapsulated in observable characteristics of workers.

Data on hours worked were obtained from the ABS Labour Force Survey. For the years 1994-95 onward, the source of data on wage rates and characteristics of workers has been the Survey of Income and Housing Costs (SIHC). For earlier years, the Income and Distribution Survey (IDS) was used.

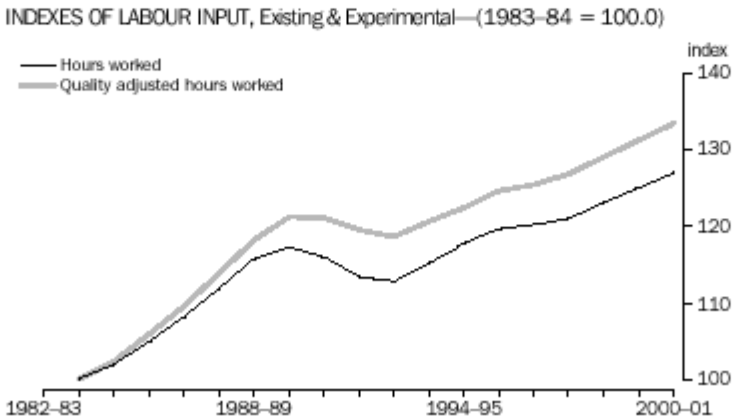
Given these assumptions and data, several methods might be used to derive the weighting factors that are applied to different classes of labour input. The weights could be based on average wages (effectively dividing the hours-worked array cell-by-cell into an array of wages paid). Or econometric methods could be used to estimate a 'wage equation', which encapsulates the relationship between wage rates and the characteristics of labour. The ABS has found that these two methods yield almost indistinguishable quality-adjusted indexes of labour input. The econometric approach is preferred as it gives more insight into the significance of the various influences on differential wage rates.

Some characteristics found to have a significant influence on differential wage rates include:

- **Educational attainment.** For this experimental compilation, five levels of attainment have been distinguished-higher degree, bachelor degree, diploma, vocational qualification and no qualification.
- **Length of workforce experience.** Ideally, one would like a measure of actual workforce experience. But this is not available in the datasets used for the experimental compilation, so a proxy measure of 'potential experience' has been constructed. The proxy measure uses a person's age and tries to take account of the years spent in education and child-rearing.

Results

The effect of adjusting labour input measures for changes in the quality of labour is illustrated in the following graph. The graph presents estimates for the 18 year period from 1983-84 to 2000-01. In the graph the existing measure of labour input is an index of hours-worked and the experimental measure is an hours-worked index adjusted for compositional changes in the quality of labour. Both indexes refer to the market sector of the economy and have been smoothed using a 3-term moving average. The 1999-2000 and 2000-01 estimates for the quality-adjusted series have been extrapolated from previous years' observations.



Some features of the results are:

- Over the 18 year period, unadjusted hours worked rose by an average compound rate of

1.3% a year, whereas quality-adjusted hours worked rose by 1.6% a year. The implied rate of quality improvement is broadly comparable with that estimated for the United States by the US Bureau of Labor Statistics.

- In the period since 1994-95 (when the SIHC was introduced), the average annual growth rate of quality-adjusted hours worked only exceeds that of the unadjusted series by 0.15 percentage points.

Conclusion

The preferred basis for compiling a quality-adjusted labour input measure is to estimate a wage equation from SIHC data. But SIHC has been run only since 1994-95, and more observations are needed to ascertain whether the experimental methods yield plausible results. Moreover, the year-to-year movements in both the unadjusted and the quality-adjusted series are somewhat volatile, and more observations are needed to understand the movements and devise the best smoothing procedures.

The quality-adjusted labour input series must be regarded as experimental for the time being. The ABS will continue compiling it for several more years, with a view to refining it and possibly incorporating it in the official productivity estimates some time in the future. For further information on this work, contact Shiji Zhao on phone (02) 6252 6053 or e-mail **shiji.zhao@abs.gov.au**.

INTERMEDIATE INPUTS AND PRODUCTIVITY GROWTH

The MFP measure for the market sector currently published by the ABS takes explicit account of just two inputs, capital and labour. A more comprehensive measure of productivity would take account of all the inputs to production, including the intermediate goods and services that are used up in the production of final goods and services.

Just as a single-factor measure of productivity (say, labour productivity) may attribute to productivity improvement the effects of other influences, such as capital deepening, so also may the two-factor measure of MFP attribute to productivity improvement the effects of other influences (such as an increase in the amount of imported goods and services relative to labour and capital input).

In compiling productivity estimates for the **whole economy**, a two-factor MFP measure may not be too misleading. That is because many of the intermediate inputs flowing between industries cancel out in aggregate-the goods and services used in production by many Australian industries are purchased from other Australian industries. Thus, an estimate of economy-wide MFP might be distorted only to the extent that changes in the intermediate inputs imported by Australia from overseas have contributed to output growth.

There is potentially a slightly more serious problem when productivity estimates for the market sector are compiled, as the ABS does at present. In that case, the MFP measure may be distorted to the extent that industries in the market sector purchase intermediate inputs either from overseas or from non-market industries (such as Property and business services) and changes in those intermediate inputs relative to capital and labour input have contributed to capital-labour MFP growth for the market sector.

A broad calculation suggests that failing to take account of intermediate inputs may lead to over estimation of market sector MFP growth by perhaps 0.1 to 0.3 percentage points a year. The distortion is smaller during growth cycles when productivity improvement is low, and larger in

cycles when productivity improvement is high. However, this figuring has been based on a modelling of the effect, not on a full reworking of the productivity calculations taking account of intermediate inputs.

When one is compiling productivity estimates for an individual industry, ignoring intermediate inputs can lead to much more serious distortions. That is because for many industries the value of intermediate goods and services purchased from outside the industry is large compared with the value of labour and capital inputs and the growth in volume of these intermediate inputs may be at quite a different rate to that of capital and labour combined.

From 1994-95, the ABS has been compiling annual supply and use tables in both current prices and in the prices of the previous year on a consistent basis. These tables (and associated measures of labour and capital input) provide the means to calculate estimates of MFP growth for individual industries and the market sector that take account of the contribution of intermediate inputs. Over the next few years the ABS will use these data to derive experimental estimates. For further information on this work, contact Shiji Zhao on phone (02) 6252 6053 or e-mail **shiji.zhao@abs.gov.au**.

ATTACHMENT A

Productivity measures from the 2000-01 issue of 5204.0-**Table 20a**

INDEXES OF PRODUCTIVITY AND RELATED MEASURES(a), Market Sector(b)

	PRODUCTIVITY			OUTPUT	INPUTS			
	Labour(c)	Capital(d)	Multifactor(e)	Gross domestic product(f)	Hours worked	Capital services	Total labour & capital(f)	Capital-labour ratio(f)
1964-65	44.4	136.1	67.7	30.9	69.6	22.7	45.6	32.6
1965-66	43.2	129.7	65.3	31.2	72.1	24.0	47.7	33.3
1966-67	44.1	130.7	66.3	33.1	75.0	25.3	49.8	33.7
1967-68	44.6	126.8	66.0	34.0	76.1	26.8	51.4	35.2
1968-69	49.1	131.9	71.1	37.8	76.9	28.6	53.2	37.2
1969-70	50.0	130.3	71.5	39.5	79.0	30.3	55.3	38.4
1970-71	51.0	127.5	71.7	41.4	81.3	32.5	57.8	40.0
1971-72	52.7	126.3	73.0	43.2	82.0	34.2	59.2	41.7
1972-73	53.8	124.4	73.5	44.3	82.3	35.6	60.3	43.3
1973-74	56.8	127.4	76.6	47.3	83.3	37.1	61.7	44.6
1974-75	58.4	122.4	76.9	47.4	81.1	38.7	61.6	47.7
1975-76	59.7	119.9	77.5	47.6	79.7	39.7	61.4	49.8
1976-77	62.5	121.6	80.3	49.5	79.1	40.7	61.6	51.4
1977-78	63.0	118.6	80.0	49.4	78.5	41.7	61.8	53.1
1978-79	65.6	119.8	82.5	51.7	78.8	43.2	62.7	54.8
1979-80	65.9	117.5	82.2	52.6	79.8	44.8	64.0	56.1
1980-81	66.2	114.8	81.7	54.0	81.6	47.1	66.1	57.7
1981-82	68.6	112.5	83.1	55.9	81.5	49.7	67.3	61.0
1982-83	67.2	102.3	79.3	52.5	78.2	51.4	66.2	65.7
1983-84	70.6	104.1	82.5	55.3	78.4	53.2	67.1	67.8
1984-85	73.3	106.7	85.2	59.0	80.6	55.3	69.3	68.6
1985-86	73.4	105.7	85.0	60.8	82.8	57.5	71.5	69.5
1986-87	71.9	102.9	83.0	61.2	85.1	59.4	73.7	69.8
1987-88	73.8	105.2	85.1	65.2	88.4	61.9	76.6	70.1
1988-89	75.7	106.0	86.7	69.3	91.5	65.3	79.9	71.4
1989-90	75.6	103.9	85.9	71.5	94.6	68.8	83.3	72.8
1990-91	77.4	100.7	86.0	71.2	92.0	70.7	82.7	76.9
1991-92	79.8	97.7	86.6	70.4	88.2	72.0	81.3	81.7
1992-93	81.6	98.2	87.9	72.5	88.8	73.8	82.4	83.1
1993-94	83.8	99.9	89.9	75.8	90.5	75.9	84.3	83.9

1994-95	84.2	100.8	90.5	79.1	94.0	78.5	87.5	83.5
1995-96	87.6	101.6	93.0	83.0	94.7	81.6	89.2	86.2
1996-97	90.4	100.2	94.2	85.9	95.0	85.7	91.2	90.3
1997-98	94.3	99.5	96.3	90.0	95.4	90.5	93.4	94.8
1998-99	97.9	99.4	98.5	94.7	96.7	95.2	96.1	98.5
1999-00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2000-01	100.3	96.8	98.9	100.2	99.9	103.5	101.4	103.5

(a) Reference year for indexes is 1999-2000 =100.0.
(b) The 'market sector' refers to ANZSIC divisions A to K and P.
(c) Gross domestic product per hour worked.
(d) Gross domestic product per unit of capital services. Experimental.
(e) Gross domestic product per unit of labour and capital. Experimental.
(f) Chain volume measure.

ATTACHMENT B

Productivity measures from the 2000-01 issue of 5204.0-**Table 20b**

COMPOUND ANNUALPERCENTAGE CHANGE BETWEEN MFP GROWTH CYCLE PEAKS, Market Sector(a)

	PRODUCTIVITY			OUTPUT	INPUTS			
	Labour(b)	Capital(c)	Multifactor(d)	Gross domestic product(e)	Hours worked	Capital services	Total labour & capital(e)	Capital-labour ratio(e)
1964-65 to 1968-69	2.5	-0.8	1.2	5.1	2.5	6.0	3.9	3.3
1968-69 to 1973-74	2.9	-0.7	1.5	4.6	1.6	5.3	3.0	3.7
1973-74 to 1981-82	2.4	-1.5	1.0	2.1	-0.3	3.7	1.1	4.0
1981-82 to 1984-85	2.2	-1.7	0.8	1.8	-0.4	3.6	1.0	4.0
1984-85 to 1988-89	0.8	-0.2	0.4	4.1	3.2	4.3	3.6	1.0
1988-89 to 1993-94	2.0	-1.2	0.7	1.8	-0.2	3.0	1.1	3.3
1993-94 to 1999-00	3.0	-	1.8	4.7	1.7	4.7	2.9	3.0
1964-65 to 1999-00	2.3	-0.9	1.1	3.4	1.0	4.3	2.3	3.3

- nil or rounded to zero (including null cells)
(a) The 'market sector' refers to ANZSIC divisions A to K and P.
(b) Gross domestic product per hour worked.
(c) Gross domestic product per unit of capital services. Experimental.
(d) Gross domestic product per unit of labour and capital. Experimental.
(e) Chain volume measure.

ATTACHMENT C

Labour input measures from the 2000-01 issue of 5204.0-**Table 21**

INDEXES OF HOURS WORKED(a), by Industry

	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01
Agriculture, forestry and fishing	95.5	95.4	94.2	96.1	98.8	102.1	96.1	100.0	96.2
Mining	106.0	113.8	110.7	110.0	109.3	107.3	106.4	100.0	98.4
Manufacturing	98.6	100.7	104.5	100.6	99.2	100.2	100.4	100.0	99.2
Electricity, gas and water supply	135.7	131.3	126.8	117.1	96.5	94.8	101.3	100.0	105.2

Construction	74.1	77.6	83.2	83.5	82.6	85.6	90.4	100.0	96.5
Wholesale trade	91.5	97.4	93.8	95.8	92.5	94.0	95.8	100.0	95.1
Retail trade	86.3	86.1	92.9	93.8	93.2	93.2	96.1	100.0	99.9
Accommodation, cafes and restaurants	75.8	79.8	85.3	87.9	91.0	91.6	92.9	100.0	108.4
Transport and storage	86.6	89.5	93.2	96.8	97.0	97.1	100.0	100.0	103.9
Communication services	69.4	77.6	87.9	95.0	98.5	87.5	90.4	100.0	105.2
Finance and insurance	93.0	93.6	93.8	96.8	96.3	94.7	98.6	100.0	102.6
Property and business services	61.8	65.4	76.5	81.1	84.1	91.3	95.4	100.0	109.6
Government administration and defence	108.4	108.9	106.0	112.3	108.8	100.6	102.3	100.0	102.7
Education	89.7	92.7	92.7	98.5	97.5	96.4	100.8	100.0	103.4
Health and community services	84.0	87.2	87.5	93.2	93.9	97.0	99.7	100.0	106.4
Cultural and recreational services	73.0	80.6	91.0	90.0	92.2	95.3	97.8	100.0	100.5
Personal and other services	80.8	81.4	86.3	90.3	90.8	97.3	96.1	100.0	97.9
All industries	86.0	88.0	91.7	93.9	94.3	95.4	97.3	100.0	101.8

(a) Reference year for indexes is 1999-2000 = 100.0.

ATTACHMENT D

Productivity measures from the 2000-01 issue of 5204.0-**Table 22**

INDEXES OF GROSS PRODUCT PER HOUR WORKED(a), by Industry

	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01
Agriculture, forestry and fishing	82.1	85.2	71.6	86.6	91.1	87.4	97.3	100.0	99.7
Mining	69.1	65.5	72.0	78.1	79.8	84.0	85.2	100.0	107.6
Manufacturing	82.5	84.5	83.1	88.3	91.4	93.5	96.9	100.0	101.3
Electricity, gas and water supply	63.5	67.9	72.2	79.3	96.0	101.1	96.0	100.0	98.0
Construction	92.7	94.1	92.2	93.2	96.7	102.6	104.1	100.0	85.4
Wholesale trade	69.5	70.3	81.1	84.3	92.1	96.2	98.3	100.0	104.2
Retail trade	86.1	89.1	86.6	89.2	94.4	97.7	99.6	100.0	100.9
Accommodation, cafes and restaurants	91.9	93.2	94.6	91.1	92.8	95.0	101.0	100.0	93.8
Transport and storage	84.8	86.7	88.3	92.0	95.8	97.4	96.2	100.0	97.1
Communication services	72.1	70.5	69.6	70.7	75.2	93.6	100.1	100.0	104.8
Finance and insurance	78.7	79.4	83.9	84.1	86.2	91.1	98.7	100.0	102.0
Property and business services	na	na	na	na	na	na	na	na	na
Government administration and defence	na	na	na	na	na	na	na	na	na
Education	na	na	na	na	na	na	na	na	na
Health and community services	93.1	93.3	97.0	96.3	98.0	98.1	98.0	100.0	96.5
Cultural and recreational services	111.1	103.0	96.3	97.3	96.5	98.8	98.6	100.0	110.6
Personal and other services	na	na	na	na	na	na	na	na	na
All industries	86.8	88.1	88.1	89.6	92.5	95.5	98.6	100.0	100.1

(a) Indexes of chain volume measures of gross product per hour worked. Reference year is 1999-2000 = 100.0.

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